

LINKAGE OF RESISTANCE TO *ERYSIPHE GRAMINIS TRITICI* AND *PUCCINIA TRITICINA* IN CERTAIN VARIETIES OF *TRITICUM VULGARE* VILL.

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In an earlier publication it was reported (Waterhouse, 1930) that the variety Thew is resistant to one physiological race of leaf rust, *Puccinia triticina* Erikss., which Waterhouse at the time designated "Aust. 1", and to one of the races of *Erysiphe graminis Tritici* March., which occurred in this country at that time. It was found in these investigations also, that when Thew was crossed with Federation the results with F_2 plants indicated that the factors for resistance to mildew and to leaf rust were linked, but the linkage value was not determined. Dr. W. L. Waterhouse kindly made available to the authors F_1 , F_2 and F_3 material that would help in determining the linkage relationship, and the data here reported are observations made on that material.

In these investigations, which were commenced in 1941, the race of *Puccinia triticina* was identical with that used in the earlier investigations and, according to Humphrey *et al.* (1939), is now designated race 95. The race of *Erysiphe graminis Tritici* to which Thew is resistant gave reactions similar to those of race 1 (Mains, 1933). Grain of F_1 and F_2 plants and of F_3 lines with appropriate parents in each case was sown in 4-inch pots, and approximately one week after sowing the first leaf was inoculated with *P. triticina* by hand in the usual way. After the rust reactions had been recorded, mildew spores were dusted on to these plants from infected plants of the variety Federation, and the combined reaction to the two organisms thus obtained.

During the early stages of the work, F_1 and F_2 plants of the crosses Thew 203* \times Kenya 745, Canberra 71 \times Thew, and Gullen 110 \times Thew were studied. The glasshouse temperatures varied between 60° and 70°F. when these data were obtained, and under these conditions Thew gave a "0" reaction with race 1 of mildew and a fleck (;) reaction with race 95 of *Puccinia triticina*. Susceptible varieties under the same conditions gave a type "4" reaction to both pathogens. On the F_1 plants the reaction of the first leaf showed that resistance to leaf rust was almost completely dominant, while the first and second leaf gave a "0" reaction to mildew like the Thew parent. The F_2 results of these crosses are presented in Table 1. From the analysis it is clear that the segregations are in a 3:1 ratio indicating a single major factor for resistance to leaf rust and mildew. It is apparent, moreover, that there is a very close association between the factors which govern resistance to the two above organisms.

Among the 2,414 plants of this group which were studied, none was found which could be classified in a recombination class and 1,816 were classed as resistant and 598 susceptible. Slight variations in reaction were observed in plants of some of the crosses. In the cross Thew \times Kenya 745, fourteen aberrant plants occurred which were unlike the parents in that they showed some rust in the absence of mildew, but in no case was a plant found fully resistant to one organism and susceptible to the other. Similarly in the crosses Canberra \times Thew and Gullen \times Thew, thirteen aberrant plants occurred in the former cross and five in the latter, but all eighteen plants showed only slight variations from their parents. From this data it would appear that while minor factors for resistance to leaf rust and powdery mildew occur, which allow some development of disease in heterozygous F_2 plants, the major factors for resistance are strongly linked so that no crossovers were obtained in a population of 2,414 plants. Further work is in progress to determine the importance of these minor factors.

* Varieties carry the University of Sydney Accession Number.

TABLE 1.
Segregation in F_2 Plants for Resistance to Leaf Rust and Powdery Mildew in
Crosses involving the Variety Thew 203.

Cross.	Resistant to Rust.	Susceptible to Rust.	
	Resistant to Mildew.	Susceptible to Mildew.	
Thew 203 × Kenya 745	809	271	
Canberra 71 × Thew	596	195	
Gullen 110 × Thew	411	132	
Total	1,816	598	
	χ^2	D.F.	P.
Deviation	0.067	1	0.70-0.80
Heterogeneity	0.127	2	0.90-0.95

The value of certain Kenya varieties of wheat as stem rust resistant parents is well known. In the early stages of their utilization in this State it was found that Kenya 744 possessed resistance to race 95 of *P. triticina* (Waterhouse, 1938). In addition, this variety was found to have resistance to race 1 of powdery mildew in the United States, a resistance which was later maintained at the University of Sydney to the same race (Watson, 1943). Several crosses have been made between Kenya 744 and stem rust susceptible varieties which were also susceptible to leaf rust and powdery mildew. F_1 plants of these crosses, which are listed in Table 2, gave reactions similar to the F_1 plants of the Thew crosses when they were inoculated with leaf rust and mildew. The F_2 populations of this series are shown in Table 2 and again clearly indicate a 3:1 ratio. In addition, all plants resistant to leaf rust were resistant to mildew and those susceptible to the former were susceptible to the latter. Among 3,423 F_2 plants no recombinations were found. The cross Florence 108 × Kenya 744 showed 9 aberrant plants which, while resistant to mildew, had small rust pustules on the first leaf, but when further tests were made on the second leaf, there was clear evidence that these plants were resistant to both organisms.

F_3 lines of two crosses were also studied. Ninety-two lines of the cross Clarendon 72 × Kenya 744, and ninety-six of Federation 107 × Kenya 744 were inoculated as seedlings with both organisms. In both crosses all lines that were homozygous resistant or susceptible to, or segregated for resistance to, leaf rust also gave this same reaction to mildew, and no recombination plants were found within any of the F_3 progenies.

TABLE 2.
Segregation in F_2 Plants for Resistance to Leaf Rust and Powdery Mildew in
Crosses involving the Variety Kenya 744.

Cross.	Resistant to Rust.	Susceptible to Rust.	
	Resistant to Mildew.	Susceptible to Mildew.	
Canberra 71 × Kenya 744	699	262	
Kenya 745 × Kenya 744	586	193	
Kenya 744 × Kenya 745	233	73	
Federation 107 × Kenya 744	276	84	
Ford 99 × Kenya 744	485	180	
Clarendon 72 × Kenya 744	433	119	
Total	2,712	911	
	χ^2	D.F.	P.
Deviation	0.040	1	0.80-0.90
Heterogeneity	8.356	5	0.10-0.20

From the data presented in Tables 1 and 2 it appears that a single major gene in Thew and Kenya 744 gives resistance to these two diseases; if not a single gene then two genes which on account of their proximity do not allow crossing over to occur with a frequency that would be detected in samples of the size used in these experiments. It is possible that conditions may be found which will increase the rate of crossing over

and so demonstrate if two factors are present in these resistant parents. This point will be investigated further as opportunity offers.

Since Thew and Kenya 744 appear to have similar factors for resistance to race 1 of powdery mildew and race 95 of leaf rust, crosses between these varieties were studied to determine the relationship between the factors. Among 2,101 F_2 plants of this cross, 1,973 were resistant to rust and mildew and 128 escaped rust infection, but were resistant to mildew. All plants were as resistant as the parents. It can be concluded that the genes in the two parents are allelic. It should be mentioned further that these varieties are representative of a varietal group possessing resistance to race 95 of leaf rust and race 1 of powdery mildew, but from preliminary data obtained, all do not have the same linkage relationship as Thew and Kenya 744. In addition, observations made during 1942 and earlier in this Institution clearly indicate that varieties exist which are resistant to race 95 of leaf rust, but fully susceptible to race 1 of powdery mildew. The relationship of this gene for leaf rust resistance to the Thew and Kenya 744 gene has not yet been determined.

SUMMARY.

Thew and Kenya 744 are resistant to race 1 of *Erysiphe graminis Tritici* and to race 95 of *Puccinia triticina*. In each variety resistance to both diseases is apparently controlled by the same gene or by two different genes which are very closely linked. The gene in Kenya 744 is allelic to that in Thew.

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